

# Introducing NIST's Center for Nanoscale Science and Technology



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(<http://cnst.nist.gov>)

## Outline

- Introducing NIST's new Center for Nanoscale Science and Technology – CNST
- CNST's Vision and Mission
- Nanotechnology – Definition and Examples
- CNST Program and Plans
  - The Research Program
  - The Nanofab
  - Program Development
- Current Status

## NIST's Center for Nanoscale Science and Technology - CNST

- In the process of being formed from
  - the Physics Laboratory's Electron Physics Group, and
  - the Electronics and Electrical Engineering Laboratory's Nanofabrication Facility Group
- In support of
  - the American Competitiveness Initiative,
  - the National Nanotechnology Initiative, and
  - the Nanomanufacturing Initiative
- Located in NIST's Advanced Measurement Laboratory

## CNST Vision

- CNST will strive to
  - *solve industry's nanomeasurement problems*
  - *facilitate innovation in nanotechnology and related frontier areas of science and technology*

## CNST Mission

- CNST will
  - *provide measurement methods, standards and technology to support all phases of nanotechnology development from discovery to production,*
  - *develop and maintain a national facility, the Nanofab, with unsurpassed nanoscale fabrication and measurement capabilities*
  - *apply a multidisciplinary approach to problem solving that involves partnering with industry, academia, and other government agencies,*
  - *serve as a hub to link the external nanotechnology community to the vast measurement expertise that exists within the NIST Laboratories, and*
  - *help to educate the next generation of nanotechnologist.*

## Using Lessons Learned

- I looked both outside of NIST and to some of NIST's most successful enterprises, NCNR, and JILA.
- NCNR is acclaimed for both its strong research program and excellent user facilities.
- JILA is renown for both its excellent research and the training of young scientists.
- I also surveyed the extensive DoE, NSF, and DoD nanotechnology centers now emerging and spoken to those in leadership positions or otherwise knowledgeable about their operation.

## CNST – Desired Characteristics

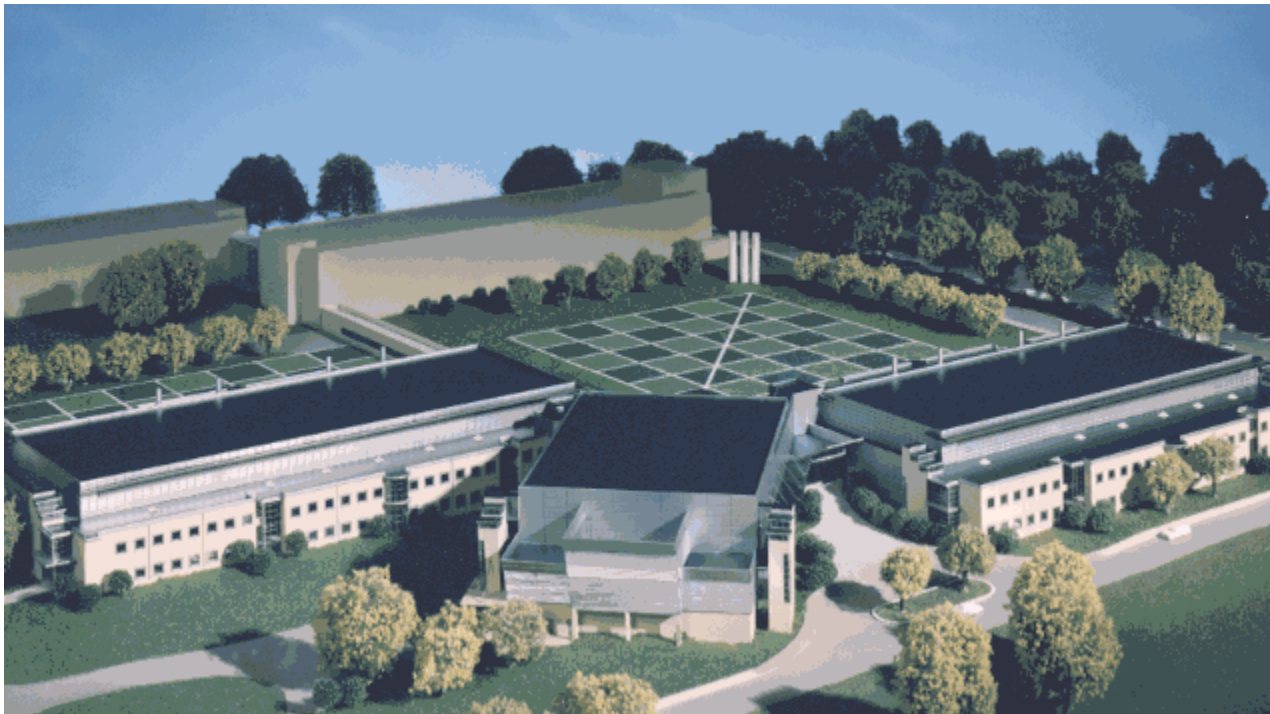
- **Multidisciplinary**
  - Problem, rather than discipline, oriented
- **Agile**
  - Able to rapidly shift program emphasis based on changes in the very, very young field of nanotechnology
  - Large postdoctoral and visitor presence
- **Focus on Measurement Science**
  - Provide measurements and methods not available anywhere else.
  - Unique capabilities, and NIST's unequalled depth in measurement science will help solve the most demanding problems of the nanotechnology community.
- **Active and stimulating intellectual atmosphere**
  - Learning, teaching, and interacting with colleagues should be easy and commonplace.
  - A large number of visitors will be encouraged, including collaborators, Nanofab users, industrial fellows, professors on sabbatical, and foreign experts.
  - There will be an active seminar program involving staff from within CNST and NIST, as well as from outside NIST.
  - Postdocs and students will exist in large numbers and meaningful interactions will be established with local universities.
  - CNST will serve as a natural focal point for nanotechnology at NIST.

## CNST – Desired Characteristics

- **Research Environment and Staff**
  - CNST will strive to hire the very best staff who understand and share the vision and measurement science mission of NIST.
  - The research staff should enjoy a great deal of autonomy and freedom to accomplish that mission.
  - “Walk-around” management style will be encouraged where managers are constantly aware of achievements, problems, and opportunities.
- **It is important that programs be developed and executed without undue delay.**
  - You cannot enable industry by lagging behind them. For that reason, each researcher should enjoy substantial level of other objects funding, as well as good electronics and computer systems support.
- **Organizational matters are very important.**
  - Another unique aspect of using our Nanofab or participating in collaborative research in CNST is the access to other measurement advice over the full spectrum of disciplines we have available. The CNST should work to make accessing NIST expertise easy for those who work with us.
- **AML Location**
  - CNST will leverage its location in one of the world’s best measurement facilities to offer unique capabilities to its partners.

## Advanced Measurement Laboratory

- CNST will leverage the facilities of the AML – arguably the world's most advanced laboratory – for its nanotechnology research.



## Nanotechnology Defined

- **The understanding and control of matter at dimensions of roughly 1- 100 nanometers, where unique phenomena enable novel applications.**
- Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.
- At the nanoscale, the physical, chemical, and biological properties of materials differ in fundamental and valuable ways from the properties of individual atoms and molecules or bulk matter.
- Nanotechnology R&D is directed toward understanding and creating improved materials, devices, and systems that exploit these new properties.

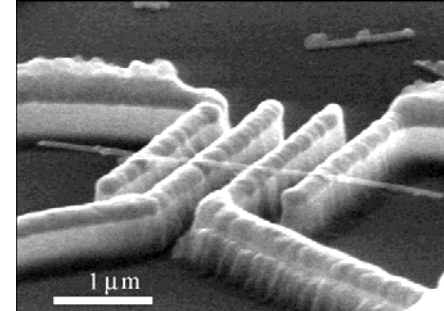
## Nanotechnology Examples

- Quantum Dots –



Frankel, MIT

- Carbon Nanotube Electronics –



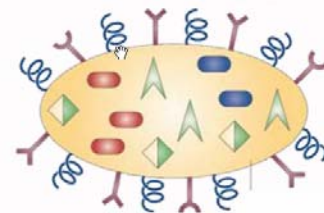
A. Bachtold, Basel

- Magnetic Storage –



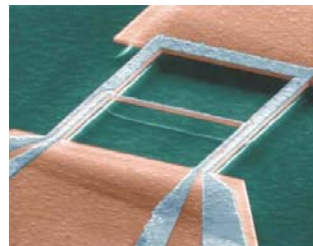
IBM

- Medical Applications –



M. Ferrari

- Sensors -



M. Roukes

## CNST Structure

- The CNST consists of a Research Program and the CNST Nanofab
  - The Research Program
    - Enabling nanotechnology with measurement solutions
  - The Nanofab
    - A National User Facility with unexcelled measurement and fabrication capabilities

## CNST's Research Program

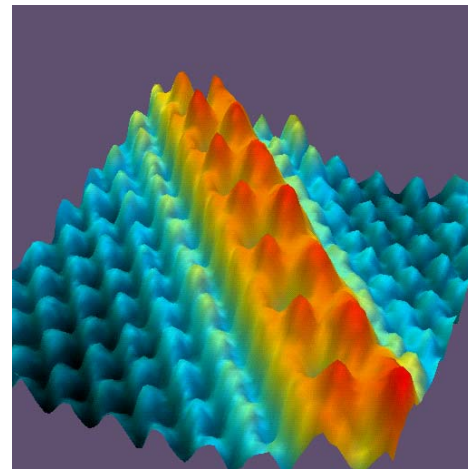
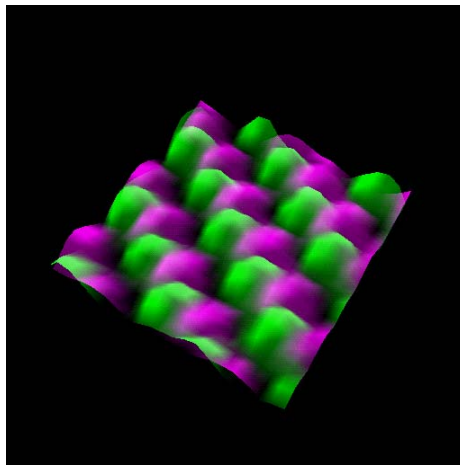
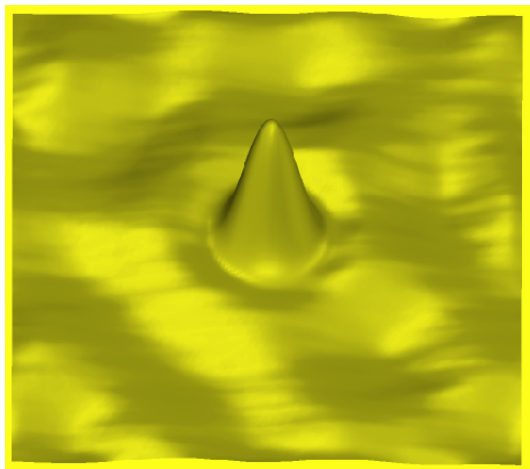
- Program areas reflect the measurement needs of emerging nanotechnologies
- Identification process is thorough and continuous
  - US Measurement System Survey
  - Government Reports (NNI, European, Asian, etc.)
  - Direct Industrial Contacts (GE, Motorola, Intel, SIA, TIA, Zyvex, Agilent, Boeing, Kimberly-Clark, etc.)
  - Research Community Input (Meetings, workshops, reports, advisory board, etc.)
  - NIST Laboratory Staff (NanoSWG, and direct contact)
  - CNST Research Staff (Leading experts in their fields)

# Initial Research Program

- Three Broad Measurement Topics
  - Bottom-up fabrication of nanostructures and devices
  - Measurement of electronic and magnetic structure on the nanoscale
  - Theory of nanoscale measurement and phenomena

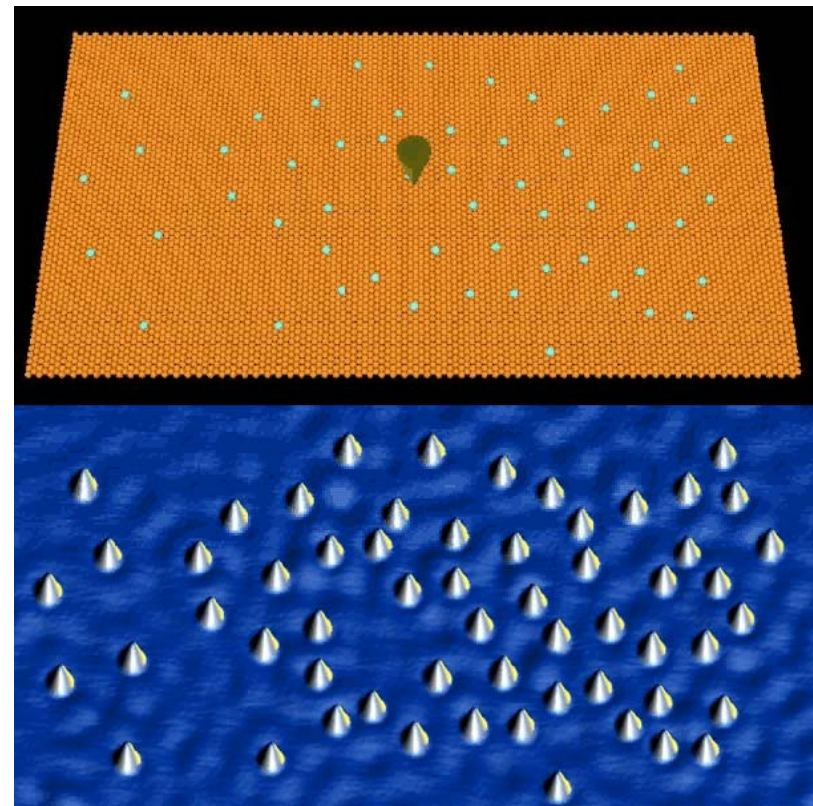
## Initial Research Program - Example

- Characterization and fabrication on the atomic scale
  - See, identify, characterize, manipulate, and assemble individual atoms!



## Initial Research Program - Example

- Characterization and fabrication on the atomic scale
  - Autonomous Atom Assembly
  - Creates *perfect* or intentionally imperfect nanostructures, atom-by-atom
  - Used to build prototypes and probe their properties



30 nm

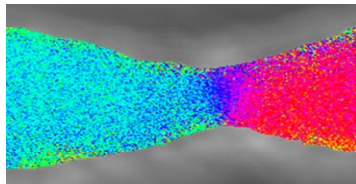
## Initial Research Program - Example

- Nanomagnetic devices
  - Memory, sensors, computers, transducers, etc.

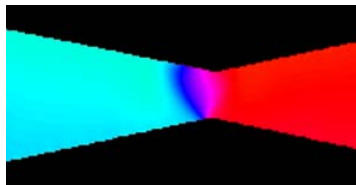


Magnetic Nano-constriction

Experiment



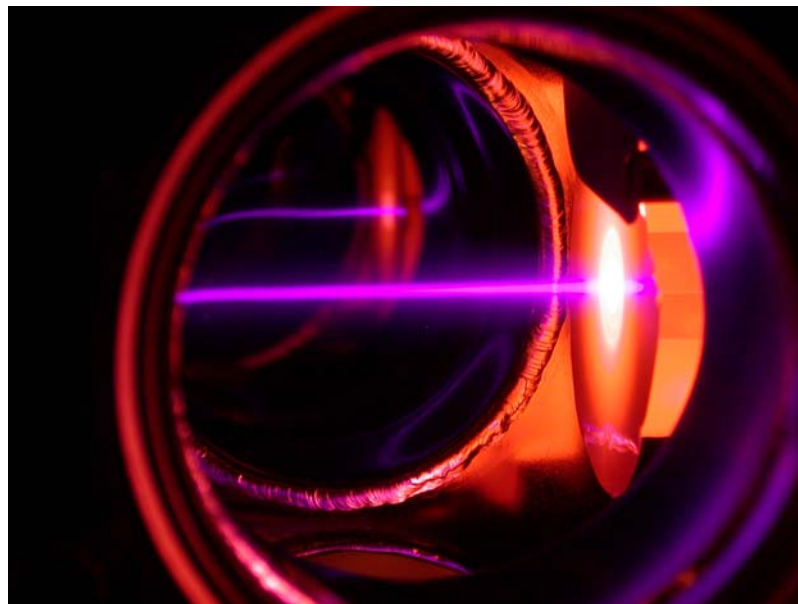
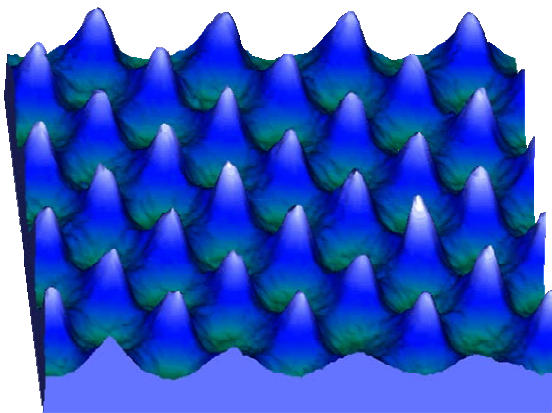
Theory



Advanced Magnetic Imaging Laboratory

## Initial Research Program - Example

- Optical Nanomeasurement and Fabrication
  - Focused Ion-Implantation and Machining
  - Precision Dopant Placement
  - Atom Based Metrology



## Research Program Expansion Underway

- Modeling nanoscale devices in macroscopic environments
  - *to show us how to access the nanoscale*
- Probing the nanoscale via atomic force microscopy
  - *for chemical and biological sensing*
- Enabling post-CMOS electronics
  - *to continue the information revolution*
- Connecting light to the nanoscale
  - *to advance communications*
- Novel lithography and nanoassembly
  - *to enable nanomanufacturing*

## CNST's Nanofab

- A state-of-the-art facility for shared use fabrication and measurement of nanostructures
  - 10,000 square foot, class 100 clean room
  - Advanced lithography and microscopy
  - Talented staff to train users or operate the tools
  - Maintains links to extensive measurement resources in the NIST Laboratories
  - Makes the expensive tools needed for nanotechnology available to NIST staff



## How will the CNST operate?

- We will
  - Identify the important measurement barriers to the development and productive use of nanotechnology
  - Work with our industrial and academic partners to find solutions to those measurement problems
  - Establish, maintain, and operate an advanced facility to provide us and our partners with the tools necessary to accomplish our goal

## CNST – Current Status

- January 2006: Reorganization proposed
- April 2006: Staff level 20
- April 2006: Recruitment actively underway
- Fall 2006: Staff level should approach 40
- Fall 2006: University participation begins
- FY07: Budget Initiative Pending

